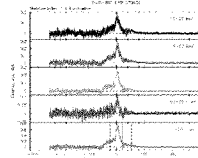**GRB Discoveries with Swift**

Neil Gehrels

NASA-GSFC

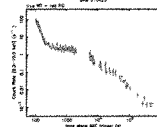*Swift* **GRB 070420**

BAT prompt emission

3 instruments, each with:
- lightcurves
- images
- spectra

XRT afterglow

Long GRBs

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63 *Swift* **Long GRB Redshifts**

6.29	050904	2.35	070110
5.47	060927	2.31	070506
5.3	050814	2.30	060124
5.11	060522	2.20	050922C
4.9	060510B	2.17	070810
4.41	060223A	2.04	070611
4.27	050505	1.95	050315
4.05	060206	1.71	050802
3.97	050730	1.55	051111
3.91	060210	1.51	060502A
3.71	060605	1.50	070306
3.69	060906	1.49	060418
3.62	070721B	1.44	050318
3.53	060115	1.31	061121
3.44	061110B	1.29	050126
3.43	060707	1.26	061007
3.36	061222B	1.17	070208
3.34	050908	0.97	070419A
3.24	050319	0.94	051016B
3.21	060926	0.84	070318
3.21	060526	0.83	050824
3.08	060607A	0.76	061110A
2.95	070411	0.70	060904B
2.90	050401	0.65	050416A
2.82	050603	0.62	070612A
2.71	060714	0.61	050525A
2.68	060604	0.54	060729
2.61	050820A	0.44	060512
2.50	070529	0.125	060614
2.45	070802	0.089	060505
2.43	060908	0.033	060218
2.35	051109A		

z	GRB	Optical/IR Brightness
6.29	050904	J = 18 @ 3 hrs
5.6	060927	I = 16 @ 2 min
5.3	050814	K = 18 @ 23 hrs
5.11	060522	R = 21 @ 1.5 hrs

GRB Host Spectroscopy

GRB 050505
z = 4.275
Damped Lyα
$N(HI)=10^{22}$ cm^{-2}
$n \sim 10^{5}$ cm^{-3}
$Z = 0.06$ Z_O
$M_{progenitor} < 25$ M_O

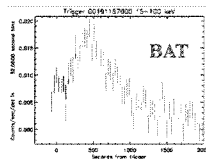### Metallicity vs Redshift
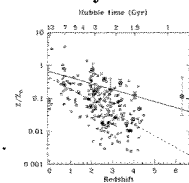
Savaglio 2006

GRB 050904 z=6.29
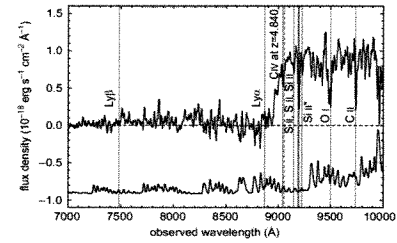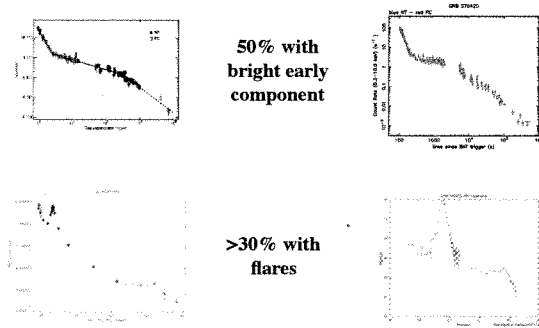

Subaru Telescope
Kowai et al. 2006

GRB 060218:   GRB + Supernova

Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

z = 0.033   d = 145 Mpc

SN 2006aj   SN Ib/c

E_{iso} = few x 10^{49} erg - **underluminous**

Afterglows

Typical *Swift* X-ray Lightcurves

50% with bright early component

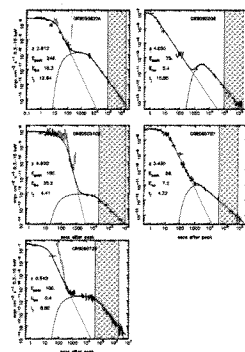**>30% with flares**

Burrows et al. 2005

Achromatic Jet Break - GRB 060526
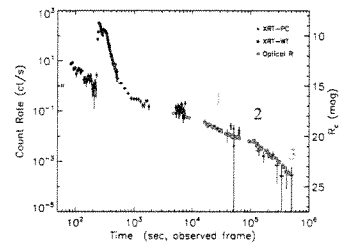
z=3.21
jet angle = 7°

Dai et al. 2007

Puzzling Data

- Many GRBs do not show jet breaks

- In other cases, optical and X-ray breaks are not coincident.

- Complex shape of afterglow lightcurves makes jet breaks hard to find
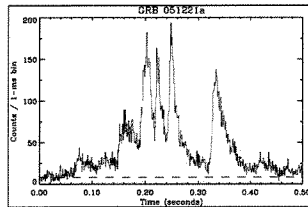
Willingale et al. 2007

Other new papers:

Curran et al. (astro-ph 0706.1188) - evidence for achromatic breaks in several Swift GRBs

Oates et al. (astro-ph 0706.0669) - GRB 050802 case with X-ray break clearly seen but no optical break

Short GRBs

Short GRB Time Structure

GRB 051221a

Short GRB - Current Status

Swift short GRB observations
- 23 short bursts detected (+ 2 from HETE, +1 from INTEGRAL)
- 78% with X-ray afterglow detected by XRT   (95% long GRBs)
- 28% with optical detection   (58% long GRBs)
- ~50% with host IDs

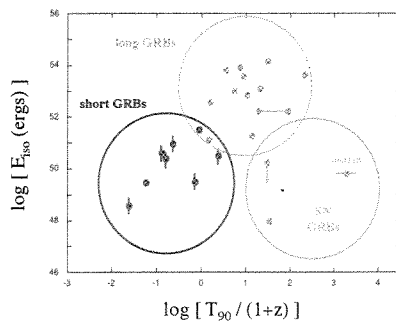~1/2 shorts accompanied by soft
  extended emission up to 100 sec

Redshift range from z = 0.2 to 1
- $<z>_{short}$ = 0.6
- $<z>_{long}$ = 2.3

GRB 070714B z = 0.92
(Graham et al. 2007)

3 Types of GRBs

Swift GRBs (mostly)

long GRBs

short GRBs

$\log [E_{iso} (ergs)]$

$\log [T_{90} / (1+z)]$

Implications for Grav. Wave Detections

Assuming all short GRBs are due to NS-NS
  mergers, merger rate is ~300 Gpc^{-3} yr^{-1}

[Concsistent with NS-NS population synthesis
  modeling O'Shaughnessy, Kalogera, &
  Belczynski (2005)]

⟹ **Advanced LIGO detection rate of ~30 yr^{-1}**

Nakar et al.:
  Possible much higher rates of 10^5 Gpc^{-3} yr^{-1}.
  ⟹ Detection with enhance LIGO

Swift will be in orbit until > 2020